Prescribed Fire and Cattle Grazing on an Elk Winter Range in Montana

Author(s): Craig S. Jourdonnais and Donald J. Bedunah
Source: *Wildlife Society Bulletin*, Vol. 18, No. 3 (Autumn, 1990), pp. 232-240
Published by: Wiley on behalf of the Wildlife Society
Stable URL: http://www.jstor.org/stable/3782207
Accessed: 30-06-2015 23:20 UTC

Wildl. Soc. Bull. 18:232–240, 1990

PRESCRIBED FIRE AND CATTLE GRAZING ON AN ELK WINTER RANGE IN MONTANA

CRAIG S. JOURDONNAIS,[1] *School of Forestry, University of Montana, Missoula, MT 59812*

DONALD J. BEDUNAH, *School of Forestry, University of Montana, Missoula, MT 59812*

The Sun River Wildlife Management Area is a major winter range for elk (*Cervus elaphus nelsoni*) in Montana. Grasslands on the management area are a complex of species, with rough fescue (*Festuca scabrella*) the most preferred forage for wintering elk (Knight 1970, Jourdonnais 1985). Rough fescue grasslands of north-central Montana's Rocky Mountain Front evolved with frequent wildfires and heavy grazing by large ungulates. Arno (1980) and Wright and Bailey (1982) estimated a fire frequency of 5 to 10 years for these forest margin grasslands. Historical records provide evidence that grazing by large ungulates was a natural and significant component of the East Front grasslands in the Sun River Wildlife Management Area (Picton and Picton 1975).

Livestock grazing was excluded from the Management Area after its establishment in 1948. The absence of fire and the selective grazing patterns of wintering elk allowed some rough fescue communities to accumulate large amounts of standing litter. Knight (1970) observed that Sun River elk preferred fescue plants free of old-growth; of all spring grazing by elk, only 2% was on Idaho fescue (*Festuca idahoensis*) and 5% was on rough fescue plants ungrazed the previous winter. Litter accumulations become a management problem when elk move from the management area to graze on private lands that do not have litter accumulations because of grazing by domestic livestock.

Our objective was to remove accumulated litter and increase forage availability and quality for elk wintering on the management area, without reducing rough fescue production. Specifically, we compared the influence of seasonal burning and fall cattle grazing on botanical standing crop and elk use of a rough fescue grassland for 3 seasons. Because rough fescue is the dominant plant and preferred elk forage, we concentrated our study on the influence of treatments on this species.

STUDY AREA AND METHODS

Research was conducted on the 8,100-ha Sun River Wildlife Management Area, located 112 km west of Great Falls, Montana. The study area is representative of the transition zone where the Great Plains meet the foothills of the Rocky Mountains. Our study area was 150 ha of a rough fescue/Idaho fescue/bluebunch wheatgrass (*Agropyron spicatum*) habitat type complex (Harvey 1980) at 1,250 m elevation. Major grasses in the study area were rough fescue, Idaho fescue, bluebunch wheatgrass, prairie junegrass (*Koeleria cristata*), Sandberg bluegrass (*Poa sandbergii*), and plains muhly (*Muhlenbergia cuspidata*). Dominant forb species included blazing star (*Liatris punctata*), silky lupine (*Lupinus sericeus*), and white prairie aster (*Aster falcatus*). Common shrubs were shrubby cinquefoil (*Potentilla fruticosa*), fringed sage (*Artemisia frigida*), common snowberry (*Symphoricarpos albus*), creeping juniper (*Juniperus horizontalis*), and silverberry (*Elaeagnus commutata*).

Topography is bench-like, sloping slightly to the southeast with gently rolling knobs and kettles. The soils are mapped as Judith-Windham stony loam (fine-loamy and loamy-skeletal, carbonatic Typic Calciborolls) (Soil Survey Staff 1975). Mean annual temperature is 6.4 C. Annual precipitation averages 38–46 cm on the foothills. Usually, one-third of the annual precipitation occurs during April, May, and June. Annual precipitation deviations from 30-year norms were −9.4 cm for 1983, −6.6 cm for 1984, +4.4 cm in 1985, and +0.10 cm in 1986, with generally below-normal precipitation during the winters and springs of the study.

Treatments

Our treatments were designed to reduce plant damage by removing standing litter while forage plants

[1] Present address: Montana Department of Fish, Wildlife, and Parks, Montana Outdoor Bldg., Helena, MT 59620.

were dormant. Treatments were a spring back-fire, spring head-fire, fall back-fire, fall head-fire, cattle grazing, and control. Plot size for the control and prescribed fire treatments was 2 ha (50 m × 400 m). The heading and backing fires were performed on 17 October 1983 and 15 April 1984. Firelines were constructed by mowing 3-m wide strips around each plot and burning these strips with a modified version of the double wet-line technique (Martin et al. 1977). Burn plots were ignited with a drip torch, and fire weather data were collected with a belt weather kit each 0.5 hour during the burning (Table 1).

The cattle-grazing treatment used 104 cow/calf pairs on an adjacent 104-ha pasture from 18 October 1983 to 22 December 1983. The cattle pasture was separated from burn and control plots by an electric fence. Forage use by cattle was measured by the paired-plot weight difference method (Klingman et al. 1943) using 6 1.0-m^2 randomly placed agronomy cages.

Botanical Measurements

Botanical biomass was measured in late September of each year by clipping 6 0.5-m^2 plots/treatment. The plots were protected from ungulate grazing by agronomy cages (1 m^2) randomly placed during the fall of the preceding growing season. Vegetation was separated by species (rough fescue, Idaho fescue, bluebunch wheatgrass) or plant group (graminoids, forbs, shrubs, standing litter, and down litter) during clipping. Standing litter was the biomass from previous growing seasons that had accumulated within the grass clumps. Down litter was considered as a previous growing season production that was on the soil surface.

Forb composition data were collected in June 1985 with a modified double sampling technique (Pechanec and Pickford 1937). Five 0.5-m^2 sample sites were randomly located on each treatment plot, and 15 were used on the grazing pasture. Standing crops are expressed as kg/ha based on an oven-dried (65 C) weight.

We measured density of rough fescue and Idaho fescue in 1986 to determine if treatments had changed the number of key forage plants. Individual plants were counted within 15 randomly located 0.5-m^2 plots/treatment. The percentage of ground surface occupied by total plants and litter was estimated within the same frame. Bareground was determined by subtracting plant cover and litter cover from 100%.

Elk Use

Elk use was estimated with 3 techniques after elk had migrated. We used the paired plot weight-estimate procedure (Klingman et al. 1943) and clipped 6 caged and 6 noncaged sample sites on each treatment in April 1985 and 1986. The differences in weight of rough fescue biomass produced in the previous growing season between caged and noncaged sample sites were expressed as percent elk utilization based on oven-dry weight. In 1986, we also estimated the utilization of spring growth of rough fescue. Our study area received little use from other ungulates, and we believe this procedure provided the most accurate measure of rough fescue use by elk.

A second estimate of forage use was determined by a modified grazed plant method (Cook and Stubbendieck 1986). The number of rough fescue and Idaho fescue plants that had been grazed was determined by randomly selecting 50 points along a transect and then recording if the nearest rough fescue plant and Idaho fescue plant were grazed. In recording the number of plants grazed, no attempt was made to estimate the amount of use of an individual plant. Six 90-m transects (2 transects/replication) were randomly placed in each treatment; the number of plants grazed is presented as a percent.

Number of elk-use days/ha was estimated by counting current season pellet groups (Neff 1968) on 6 2-m × 90-m transects randomly located on each treatment (2 transects/replication). Because treatment plots were relatively small, elk use in days/ha was used to compare use of the study area between years, not to determine treatment differences within a year.

Table 1. Fire weather and fuel moisture data for the fall 1983 and spring 1984 prescribed burns on the Sun River Wildlife Management Area in Montana.

Climatological variables	Fall	Spring
Maximum temperature (C)	10.0	15.5
Minimum temperature (C)	7.2	6.1
Maximum relative humidity (%)	50.0	50.0
Minimum relative humidity (%)	37.0	27.0
Mean wind speed (km/h)	8.8	3.2
Fine fuel moisture at ignition (%)	6.3	4.3
Fine fuel moisture at completion (%)	7.4	8.7

Experimental Design and Statistical Analysis

Prescribed fire treatments and the control were replicated 3 times in a completely randomized design. The cattle-grazing treatment was not replicated because of the expense of having replicated pastures and cattle herds. Therefore, our measures of variance for the cattle-grazing treatment are from samples within the treatment and are subject to the problems of pseudoreplication (Hurlbert 1984). Recognizing the potential for such problems we analyzed the data with and without the cattle-grazing treatment. We found no instances where our conclusions differed when the cattle-grazing treatment was included, so we presented our results based on replicated samples for the control and prescribed fire treatments and on pseudoreplicated samples for the cattle-grazing treatment.

Table 2. Influence of prescribed fire and cattle grazing on the major forage species (kg/ha), vegetation classes (kg/ha), and mean biomass of litter (kg/ha) in 1984, 1985, and 1986 on the Sun River Wildlife Management Area in Montana.

	1984			1985			1986		
	Control	Prescribed fire	Cattle grazed	Control	Prescribed fire	Cattle grazed	Control	Prescribed fire	Cattle grazed
Festuca scabrella	664A[a]	317B	278B	1,155A	1,080A	761A	816A	828A	704A
Festuca idahoensis	154A	116A	107A	147A	33A	66A	121A	61A	41A
Agropyron spicatum	44A	70AB	104B	66B	91B	39B	51B	92B	65B
Misc. graminoids[b]	81A	70A	95A	27A	60A	37A	56A	65A	55A
Total forbs	268AB	281A	187B	118A	248A	234A	272A	312A	250A
Total shrubs	14A	9A	30B	22B	51B	29B	55B	115B	77B
Standing crop[c]	1,221A	862B	788B	1,534A	1,562A	1,166A	1,371A	1,470A	1,192A
Standing litter	1,047A	20B	205C	1,481A	170C	91C	499A	82C	191C
Down litter	1,939A	458B	1,602A	3,049A	396C	2,249B	1,755A	591B	1,121A

[a] Means in rows followed by different letters are different ($P \leq 0.10$).
[b] Sum of remaining graminoid and grass-like species.
[c] Sum of total grasses, total forbs, and total shrub categories.

Table 3. Influence of prescribed fire and cattle grazing on mean density (plants/m^2) of rough fescue (*Festuca scabrella*) and Idaho fescue (*F. idahoensis*) and coverage (%) of litter, total living plants, and bareground 3 years post-treatment in 1986 on the Sun River Wildlife Management Area in Montana.

	Treatment		
Density and cover	Control	Prescribed fire	Cattle grazing
Density (number/m^2)			
Rough fescue	12.9A[a]	13.9A	13.4A
Idaho fescue	11.4A	12.2A	11.1A
Coverage (%)			
Litter	43.2A	19.6B	44.8A
Total plant	41.5A	45.5A	43.4A
Bareground	15.3A	34.9B	11.8A

[a] Means in the same row followed by different letters are different ($P \leq 0.10$).

When analysis of variance showed treatment effects at the 0.10 level of probability, we used a Duncan's new multiple-range test (Steel and Torrie 1980) to test all possible comparisons between means.

RESULTS

We found few differences between the types of burn (head fire vs. backing fire) or season of burn (spring vs. fall). Environmental conditions between seasons were similar, and all burns were initiated when major forage species were dormant to minimize treatment stress. Because most measured variables between types and season of burns were similar, we present our results of the burn treatments as a group.

Botanical Measurements

The cattle-grazed and prescribed fire (burn) treatments reduced rough fescue biomass, total standing crop, and standing litter compared with the control in the first growing season post-treatment (Table 2). By the second and third post-treatment growing season, there were no differences between treatments in biomass of any grass species, total shrubs, or total forbs (Table 2). Standing and down rough fescue litter remained greater on the control than on the burn and cattle-grazed treatments in 1985 and 1986; the down litter in the cattle-grazed treatment was intermediate between the control and burn treatments. The increase in rough fescue between 1984 and 1985 was 361% for the burn treatments, 274% for the cattle-grazing treatment, and 174% for the control.

Densities of rough and Idaho fescue and total plant cover were similar in all treatments 3 years post-treatment (Table 3). The amount of bareground, however, was greater on the burns compared with the control and cattle-grazing treatments 3 growing seasons post-treatment.

Although there were no differences in total forb standing crop between treatments, 3 forb species did have different responses to season of burning. White prairie aster and blazing star had greater biomass on spring burns compared with fall burns. Nodding onion (*Allium cernuum*) standing crop was greater on fall burns than spring burns.

Elk Use

During the winter of 1983–1984, elk use of the study area averaged 16 days/ha. We found more rough fescue plants grazed by elk in the fall burn treatments, although actual use (% weight lost) was believed minimal. By the winter of 1984–1985, elk use had increased dramatically, averaging 96 days/ha, and the percent of rough fescue plants grazed averaged 95% across treatments (Fig. 1).

Utilization (by % weight lost) of rough fescue was greater on burn and cattle-grazed treatments than on the control in the winter of 1984–1985 (Fig. 2). In the winter of 1985–1986, utilization of rough fescue was greater in the burn treatments than in the control. Idaho fescue also received significant use by elk, and the percent of Idaho fescue plants grazed by elk was greater on burn and cattle-grazed treatments than on the control (Fig. 1).

Elk use of rough fescue averaged across treatments was 82% in 1985–1986, compared with 68% for the previous winter (Fig. 2.). On

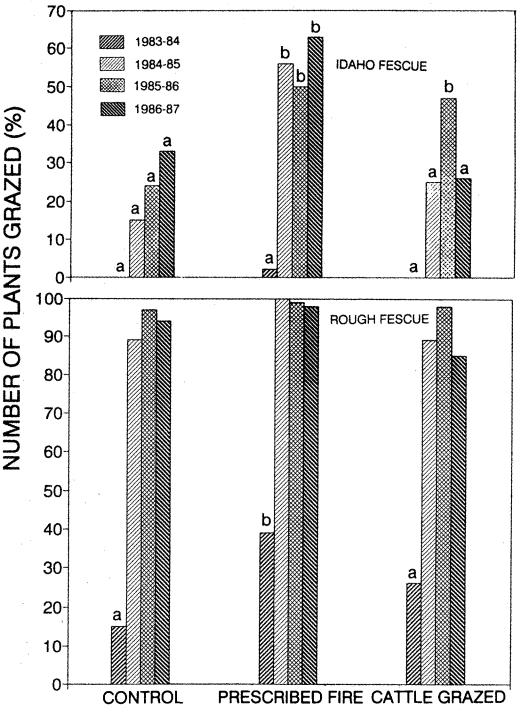

Fig. 1. Number (%) of rough fescue (*Festuca scabrella*) and Idaho fescue (*F. idahoensis*) plants that were grazed during the winters of 1983–1984, 1984–1985, 1985–1986, and 1986–1987 in the control, prescribed fire, and cattle-grazed treatments on the Sun River Wildlife Management Area in Montana. Within each year and species the bars with different letters were different ($P \leq 0.10$). No differences were found ($P > 0.10$) between treatments in 1984–1985, 1985–1986, or 1986–1987 for rough fescue.

25 April 1986, the current year's standing crop of rough fescue averaged 484 kg/ha across treatments, and utilization (% weight lost) averaged 51% across treatments (Table 4).

In the winter–spring of 1986–1987, the percent of rough fescue plants that were grazed averaged 95% across treatments (Fig. 1) and use of spring growth was high (Table 4). Idaho fescue had also received substantial amounts of grazing by elk, especially on the burn treatments (Table 4). We did not measure weight of rough fescue utilized in winter–spring 1986–1987, but visual observations indicated very heavy use. Bluebunch wheatgrass was the

Table 4. Influence of prescribed fire and cattle grazing on the spring use (weight utilized) of rough fescue (*Festuca scabrella*) in 1986 and the number of rough fescue and Idaho fescue (*F. idahoensis*) plants with spring growth grazed (%) in 1987 on the Sun River Wildlife Management Area in Montana.

	Treatment		
Utilization	Control	Prescribed fire	Cattle grazing
Rough fescue			
1986 (weight)	52A[a]	54A	35B
1987 (%)	76A	88B	45C
Idaho fescue			
1987 (%)	7A	24B	12AB

[a] Means in the same row followed by different letters are different ($P \leq 0.10$).

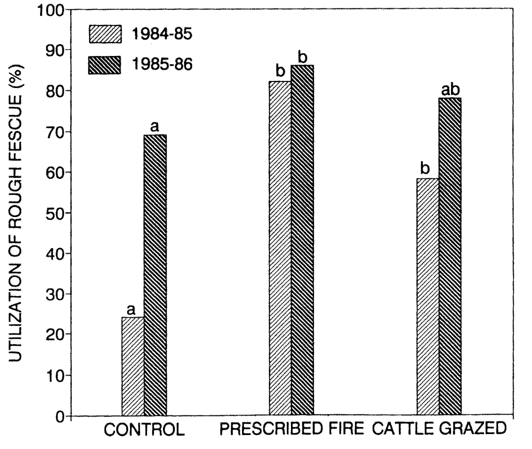

Fig. 2. Utilization (% weight lost) of rough fescue (*Festuca scabrella*) during the winter-spring of 1984–1985 and 1985–1986 in the control, prescribed fire and cattle-grazed treatments on the Sun River Wildlife Management Area in Montana. Within each year the bars with different letters were different ($P \leq 0.10$).

dominant remaining forage and received little use by elk, especially when seed culms were present.

DISCUSSION

Botanical Measurements

The decline in rough fescue in response to burning was attributed to heavy accumulations of down litter, which prolonged combustion next to rough fescue stem bases. The heavy litter created a nearly continuous mat of fuel, which allowed head and backing fires to blacken the majority of each burn plot. Some rough fescue bunches smoldered for 20 minutes after the passage of the flaming front. In addition, the drought of 1983–1984 may have increased treatment stress. Because of the dry conditions, production on the controls was only about 50% of that found during an average year.

The reduction in rough fescue biomass on the cattle-grazed treatment was caused by stem base removal and trampling. Cattle initially selected rough fescue plants that had less litter and usually removed all standing litter from such plants. Many rough fescue plants had enough down litter within the bunch to discourage close grazing; however, cattle were effective at removing the majority of standing litter without decreasing down litter.

Rough fescue had recovered from the burn and cattle-grazed treatments within 1 year. Our findings support Bailey and Anderson (1978), who found that fire reduced coverage of rough fescue for 1–3 growing seasons, depending on the season of the burn and stage of rough fescue growth. We believe that recovery of the graminoids was hastened by the unusual precipitation pattern of 1985, which resulted in record precipitation during August and September. This resulted in significant fall growth of most plant species, especially cool-season bunchgrasses such as rough fescue, Idaho fescue, and bluebunch wheatgrass.

Creeping juniper, white prairie aster, blazing star, and nodding onion were forbs and shrubs that showed significant fire effects. Most individual juniper plants were not ignited by the fire; however, a more intense fire would probably cause more damage to the juniper, which could be a concern because mule deer use juniper on parts of the Sun River Wildlife Management Area. White prairie aster and blazing star are warm-season perennials that may not have been dormant during the fall burns. Nodding onion emerges during early spring and thus may be harmed by spring burns. Although season of burn influenced the standing crop of 3 forb species, there were only minimal differences in frequencies. We do not believe our treatments would have a significant long-term effect on any forb species.

We believe that the burn treatments did not detrimentally affect Idaho fescue or bluebunch wheatgrass. The variability in biomass measurements was high for these species, and more samples may have been needed; but Blaisdell (1953), Humes (1960) and Antos et al. (1983) also found no effect of fire on bluebunch wheatgrass, and Daubenmire (1975) found no effect on Idaho fescue. Other studies have shown deleterious effects of fire on Idaho fescue (Blaisdell 1953, Countryman and Cornelius 1957, Humes 1960, Conrad and Poulton 1966, Wright et al. 1979, Antos et al. 1983) and bluebunch wheatgrass (Conrad and Poulton 1966, Daubenmire 1975), but the majority of these studies were associated either with wildfire or with sites more xeric than our study area.

On our site, bluebunch wheatgrass rarely accumulated large amounts of plant litter. Idaho fescue produced a fine-leaved litter that decomposed more rapidly than rough fescue litter. Severe root crown injury of Idaho fescue or bluebunch wheatgrass root crowns by burn treatments was rare. For Idaho fescue, we found no difference in density between treatments and we observed no severe root crown injury following burning. Similarly, Antos et al. (1983) found that rough fescue is more severely damaged by fire than Idaho fescue following prolonged fire-free intervals on the mesic foothill regions of Montana.

The greater bluebunch wheatgrass and shrub biomass in the cattle-grazed treatment compared to the control 1 growing season post-treatment was attributed to light cattle grazing on these species and heavy utilization of rough fescue. The heavy utilization of rough fescue decreased rough fescue growth, which would increase the amount of water and nutrients for the growth of bluebunch wheatgrass and shrubs.

We attribute the increase in bareground on burn treatments to the decrease in down litter, not to a decrease in live-plant cover. More bareground on the burn treatments could result in greater soil loss through wind erosion. Chinook winds of more than 100 km/hr are common along the Rocky Mountain Front. Soil deposits on the leeward side of plants in the burns, especially on the fall burns, were evident. Because of observed soil movement in fall burn treatments, we advise against burning rough fescue communities along the Montana front range during the fall.

Elk Use

The minimal use of the study area in the winter of 1983–1984 was attributed to the mild winter weather, combined with the fact that the spring burns had not been completed and the vegetation had not had time to respond to fall burn and cattle-grazing treatments. The increased use of the study area in the winter of 1984–1985 was a result of the treatments' removal of accumulated plant litter from the rough fescue bunches, thereby, making current growth of rough fescue more accessible to the elk. Wright and Bailey (1982) stressed that 1 of the major beneficial effects of burning grassland is to attract animals to grasses that are normally too coarse or contain too much litter to be palatable. Burning has been shown to increase nutrient content of shrubs (Lay 1957, Asherin 1973, Stransky and Halls 1978); however, the increase in protein content of grasses is slight and short-lived (Hilmon and Hughes 1965, Wright and Bailey 1982, Jourdonnais 1985) and probably not a major factor in increasing use of rough fescue for our study site.

Although there were few statistical differences in rough fescue use between the cattle-grazed and burn treatments, we observed that elk initially used plants on the burn treatments because of a lack of old litter. It was apparent that plants with large amounts of old litter, which we defined as plant material older than the previous growing season, were not grazed as often or as extensively as rough fescue plants with less litter. We believe the close proximity of the prescribed fire and cattle-grazed treatments to the controls probably increased elk use of the control by attracting elk to the study area. It was apparent that elk initially grazed rough fescue clumps that did not have old litter, but as forage became more limiting elk made significant use of rough fescue clumps that had substantial old litter. This was evident by the winter of 1985–1986 when the entire study area, which received very little use before our study, was becoming heavily utilized by elk. Therefore, differences in use of rough fescue between the control and litter reduction treatments were probably greater than our data suggest. For areas with large litter accumulations, managers could apply litter reduction treatments to small areas to act as a big-game lure. Attracting animals to the area in sufficient numbers would reduce standing litter through pawing and grazing.

A comparison of winter–spring 1983–1984 (initial year of treatments) and winter–spring 1986–1987, both very mild winters, showed much heavier elk use in 1986–1987. Therefore, either the number of elk days was greater on the Sun River area or elk were concentrating on the study area because of the removal of the litter, or both of these factors may have combined to cause increased use of our study area. The low amount of rough fescue forage remaining after the elk migrated was a concern because of the potential need for additional forage. For example, assuming that elk need 5.5 kg of dry matter/day, the treatment area had only 8.7 elk days/ha, 15.0 elk days/ha, and 27.5 elk days/ha of rough fescue forage remaining for the burn, cattle-grazed, and control treatments, respectively, following the winter of 1985–1986. We believe the increased use of Idaho fescue in 1986–1987 compared with other years is additional evidence of increased grazing pressure and possible overuse of this site by elk.

Heavy use of dormant forage plants is known to be less damaging than concentrated use in the growing season. On our site, it was common to see rough fescue plants defoliated below a 5-cm stubble height; on 25 April 1986, use (dry weight) of rough fescue's new growth averaged 51%. This amount of early spring use is a concern because of possible damage to rough fescue plant health and long-term site productivity. Reserve carbohydrates in rough fescue are at low levels in April and May (Jourdonnais 1985), and frequent defoliation would leave little reserve food for regrowth following repeated defoliation in the spring. Lowered carbohydrate levels result in decreased leaf area replacement and therefore less photosynthetic area and growth rate (Walton 1983). McLean and Wikeem (1985) also presented evidence of the harmful effects of spring defoliation on rough fescue; they found that clipping rough fescue to 5 cm weekly from 15 April to 15 June, or from 15 April to 15 May and once in September, resulted in 25% and 27% mortality, respectively. Therefore, the heavy spring use of rough fescue by elk, combined with very heavy winter grazing, will probably be detrimental to rough fescue production on our study area.

SUMMARY

Prescribed fire and fall cattle-grazing treatments were applied during fall 1983 and spring 1984 on a rough fescue community to reduce litter accumulations and increase elk use. Burn and cattle-grazing treatments reduced rough fescue standing crop, the preferred winter elk forage, during the initial growing season. By the second growing season, the rough fescue standing crop was similar to the control in all treatments. The control continued to have more standing and down rough fescue litter compared with other treatments. The cattle-grazing treatment maintained more down litter ac-

cumulations than the burn treatments. Total forb, total shrub, and graminoid standing crops were similar for all treatments in the second and third growing seasons after treatment.

Elk use of the study area was limited to late fall, winter, and early spring and was greater in the burn and cattle-grazed treatments compared with the control. Elk use of rough fescue was concentrated on plants without heavy litter. Idaho fescue received significant use by elk only after rough fescue was heavily utilized. Bluebunch wheatgrass and other native species received little or no use. Cattle grazing was not as effective in reducing the accumulated plant litter as the burning treatments; however, cattle grazing created a mosaic of heavy to lightly grazed areas while maintaining litter cover on the soil surface.

Few differences were found in botanical biomass or elk use among the different seasons of burn and types of burn. However, when burning is a management option to improve forage use of grasslands with large amounts of accumulated litter, we believe that implementing fires during years of normal to above-normal precipitation is desirable. For these foothill rough fescue grasslands, we suggest a spring burn. The spring burn should be applied as soon after snowmelt as possible because prescribed burning may decrease rough fescue production for at least 3 years following a late spring burn (Bailey and Anderson 1978). Removing vegetation with a fall burn increases the chances of soil erosion by wind and water, does not leave plant biomass to hold snow and provide moisture during spring melt, could increase frost damage, and leaves no forage for the elk during the initial winter after burning.

Acknowledgments.—Research was supported by the Cobb Foundation, Montana Department of Fish, Wildlife, and Parks, and the Montana Forest and Conservation Experiment Station. We thank B. Goodman, Manager of the Sun River Wildlife Management Area, and R. Wakimoto of the University of Montana School of Forestry for their assistance.

LITERATURE CITED

ANTOS, J. A., B. MCCUNE, AND C. BARA. 1983. The effect of fire on an ungrazed western Montana grassland. Am. Midland Nat. 110:354–364.

ARNO, S. F. 1980. Forest fire history in the Northern Rockies. J. For. 78:460–465.

ASHERIN, D. A. 1973. Prescribed burning effects on nutrition, production, and big game use of key northern Idaho browse species. Ph.D. Dissertation. Univ. Idaho, Moscow. 96pp.

BAILEY, A. W., AND M. L. ANDERSON. 1978. Prescribed burning of a *Festuca-Stipa* grassland. J. Range Manage. 31:446–449.

BLAISDELL, J. P. 1953. Ecological effect of planned burning of sagebrush-grass range on the upper Snake River Plains. U.S. Dep. Agric. Tech. Bull. 1063. 37pp.

CONRAD, E. C., AND C. E. POULTON. 1966. Effect of wildfire on Idaho fescue and bluebunch wheatgrass. J. Range Manage. 19:138–141.

COOK, C. W., AND J. STUBBENDIECK, EDITORS. 1986. Range research: basic problems and techniques. Soc. for Range Manage., Denver, Colo. 317pp.

COUNTRYMAN, C. M., AND D. R. CORNELIUS. 1957. Some effects of fire on a perennial range type. J. Range Manage. 10:39–41.

DAUBENMIRE, R. 1975. Plant succession on abandoned fields, and fire influences, in a steppe area in southeastern Washington. Northwest Sci. 49:36–48.

HARVEY, S. J. 1980. The potential and current vegetation of the Sun River game range. Printed in cooperation with Fed. Aid Wildl. Restor. Proj. W-130-R and the Allan Found. Mont. Dep. Fish, Wildl., and Parks, Wildl. Div., Helena. 82pp.

HILMON, J. B., AND R. H. HUGHES. 1965. Fire and forage in the wiregrass type. J. Range Manage. 18: 251–254.

HUMES, H. R. 1960. The ecological effect of fire on natural grassland in western Montana. M.S. Thesis. Univ. Montana, Missoula. 89pp.

HURLBERT, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecol. Monogr. 54:187–211.

JOURDONNAIS, C. S. 1985. Prescribed fire and cattle grazing influences on the vegetation and elk use of a rough fescue community. M.S. Thesis. Univ. Montana, Missoula. 100pp.

KLINGMAN, D. L., S. R. MILES, AND G. O. MOTT. 1943. The cage method for determining consumption and yield of pasture herbage. J. Am. Soc. Agron. 35:739–746.

KNIGHT, R. 1970. The Sun River elk herd. Wildl. Monogr. 23. 66pp.

LAY, D. W. 1957. Browse quality and the effects of prescribed burning in southern pine forests. J. For. 55:342–347.

MARTIN, R. E., S. E. COLEMAN, AND A. H. JOHNSON. 1977. Wetline technique for prescribed burning in rangeland. U.S. Dep. Agric. For. Ser. Res. Note PNW-292. 4pp.

McLean, A., and S. Wikeem. 1985. Rough fescue response to season and intensity of defoliation. J. Range Manage. 38:100–103.
Neff, D. J. 1968. The pellet-group technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32:597–614.
Pechanec, J. F., and G. D. Pickford. 1937. A comparison of some methods used in determining percent utilization of range grasses. J. Agric. Res. 54: 753–765.
Picton, H. D., and I. E. Picton. 1975. Saga of the Sun: a history of the Sun River elk herd. Printed in cooperation with Fed. Aid Wildl. Restor. Proj. W-130-R and the Allan Found. Mont. Dep. Fish, Wildl. and Parks, Wildl. Div., Helena. 54pp.
Soil Survey Staff. 1975. Soil taxonomy. A basic system of soil classification for making and interpreting soil surveys. Agr. Handb. 436, U.S. Dep. Agric., Soil Cons. Serv., U.S. Gov. Print. Office, Washington, D.C. 754pp.
Steel, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill Co., New York, N.Y. 633pp.
Stransky, J. J., and L. K. Halls. 1978. Browse quality affected by pine site preparation in east Texas. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 30:507–512.
Walton, P. 1983. Production and management of cultivated forages. Reston Publ. Co., Reston, Va. 336pp.
Wright, H. A., and A. W. Bailey. 1982. Fire Ecology: United States and southern Canada. John Wiley and Sons, New York, N.Y. 499pp.
———, L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: a state-of-the-art review. U.S. For. Serv. Gen. Tech. Rep. INT-58. 48pp.

Received 24 April 1989.
Accepted 20 February 1990.

***Wildl. Soc. Bull.* 18:240–245, 1990**

RESPONSE OF KEY FOODS OF CALIFORNIA QUAIL TO HABITAT MANIPULATIONS

KEVIN L. BLAKELY,[1] ***Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331***

JOHN A. CRAWFORD, ***Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331***

R. SCOTT LUTZ,[2] ***Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331***

KEVIN M. KILBRIDE, ***Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331***

Food supply was identified by Leopold (1977) as a factor that may limit California quail (*Callipepla californica*) populations. Emlen and Glading (1945) stated that quail numbers fluctuated with the abundance of food if adequate cover was available. In the Willamette Valley, Oregon, Oates (1979) found that quail abundance and productivity were related to the availability of certain key foods, primarily annual forbs.

In mesic portions of the range of California quail (from northwestern California through western Oregon and Washington to British Columbia), early seral stage grasslands and cultivated areas are preferred habitats (Barclay and Bergerud 1975, Crawford 1978). Management of these habitats necessitates frequent

[1] Present address: Oregon Department of Fish and Wildlife, 3814 Clark Blvd., Ontario, OR 97914.
[2] Present address: Department of Range and Wildlife, Texas Tech University, Lubbock, TX 79409.